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# Histology of the Male Reproductive System

**M1 - Endocrine/Reproduction Sequence**

**A. Kent Christensen**

**Department of Cell and Developmental Biology  
University of Michigan Medical School**

Winter, 2009



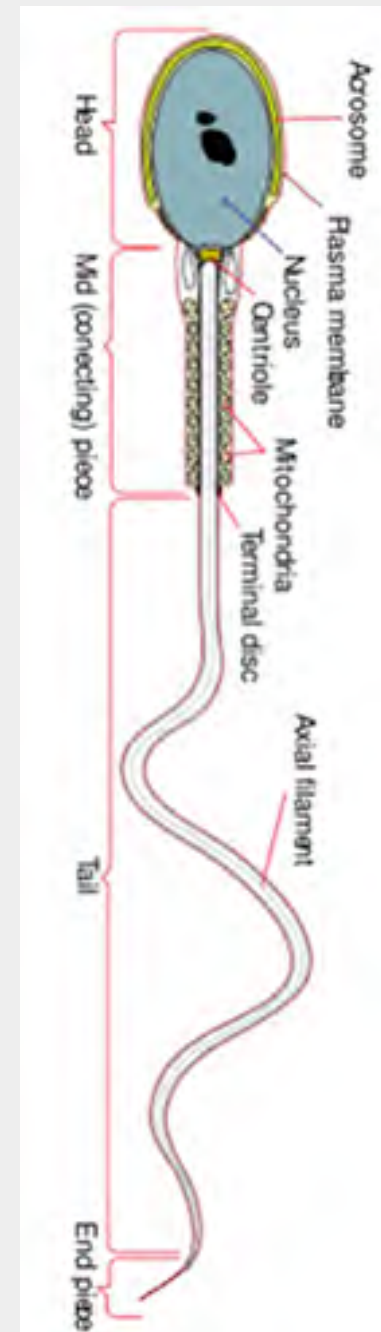
# Male reproductive system

- **Sperm**
- **Sperm production in the testis**
  - **Spermatogenesis**
    - **Meiosis**
    - **Spermiogenesis**
- **Sertoli cell**
- **Leydig cell (source of testosterone)**
- **Hormonal regulation of the male system**
  - **Testosterone**
  - **Pituitary hormones (LH, FSH)**
- **The male reproductive tract**
- **Passage of sperm to the site of fertilization**

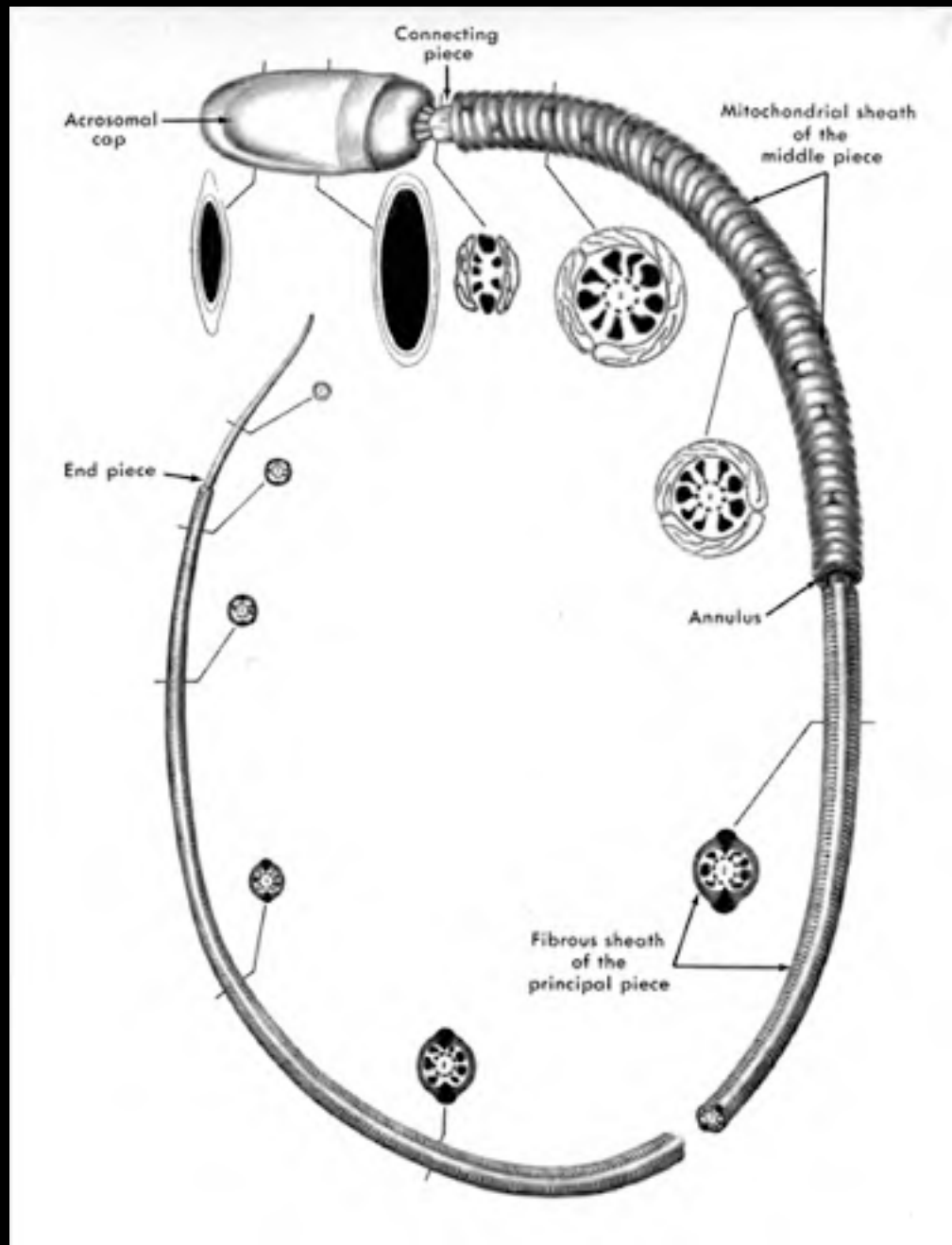
# Sperm

(About 65  $\mu\text{m}$  long)

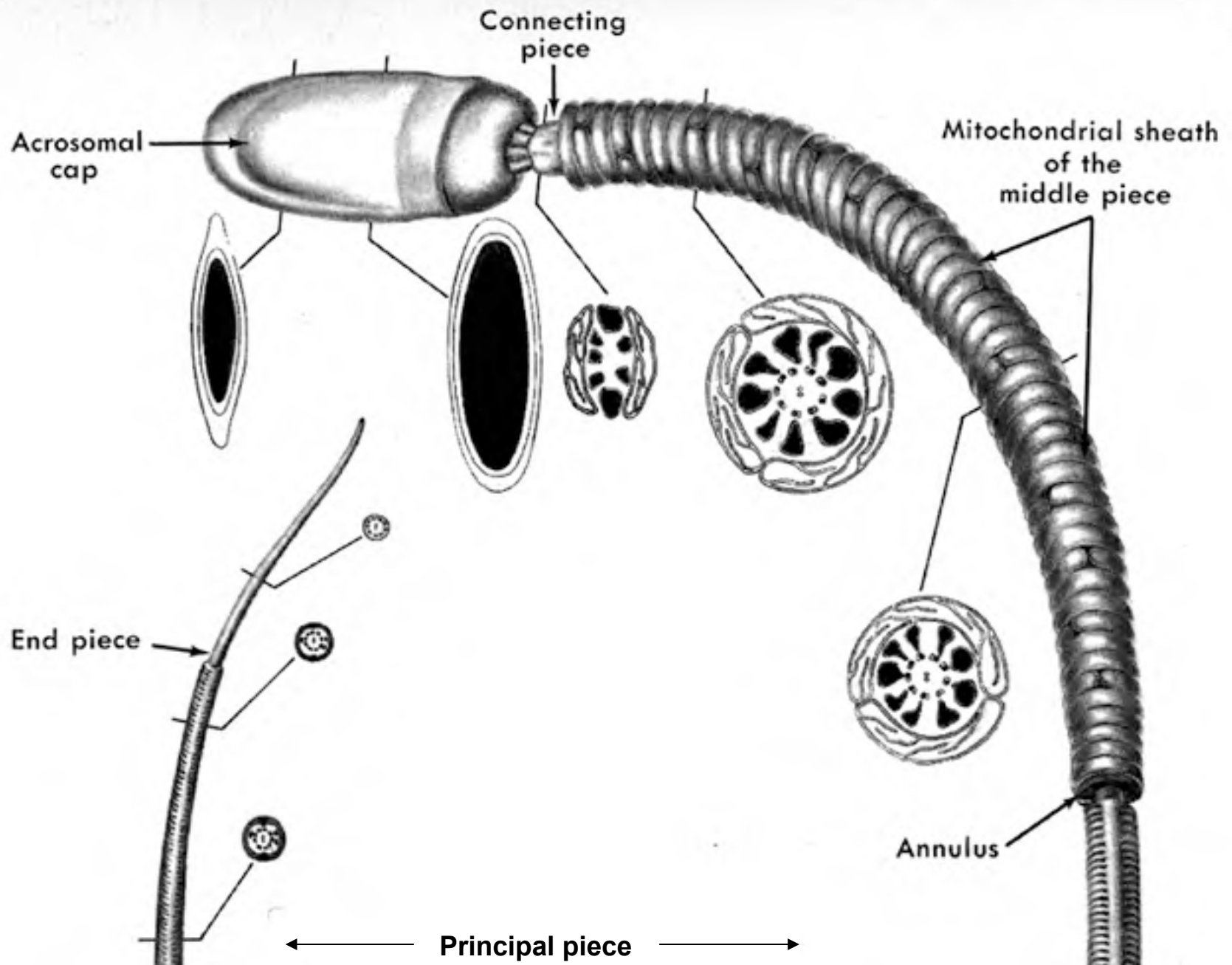
- **Head**
  - Nucleus: tightly-packed 23 chromosomes.
  - Acrosome: Flattened sac containing digestive enzymes.
- **Tail**
  - Central core is a typical flagellum (9+2=axoneme). Dense fibers.
  - Middle piece: Helically wound mitochondria.
  - Principal piece: Fibrous sheath (for support).
  - End piece: End of flagellum.
- **Plasma membrane.**



# Sperm, EM drawing

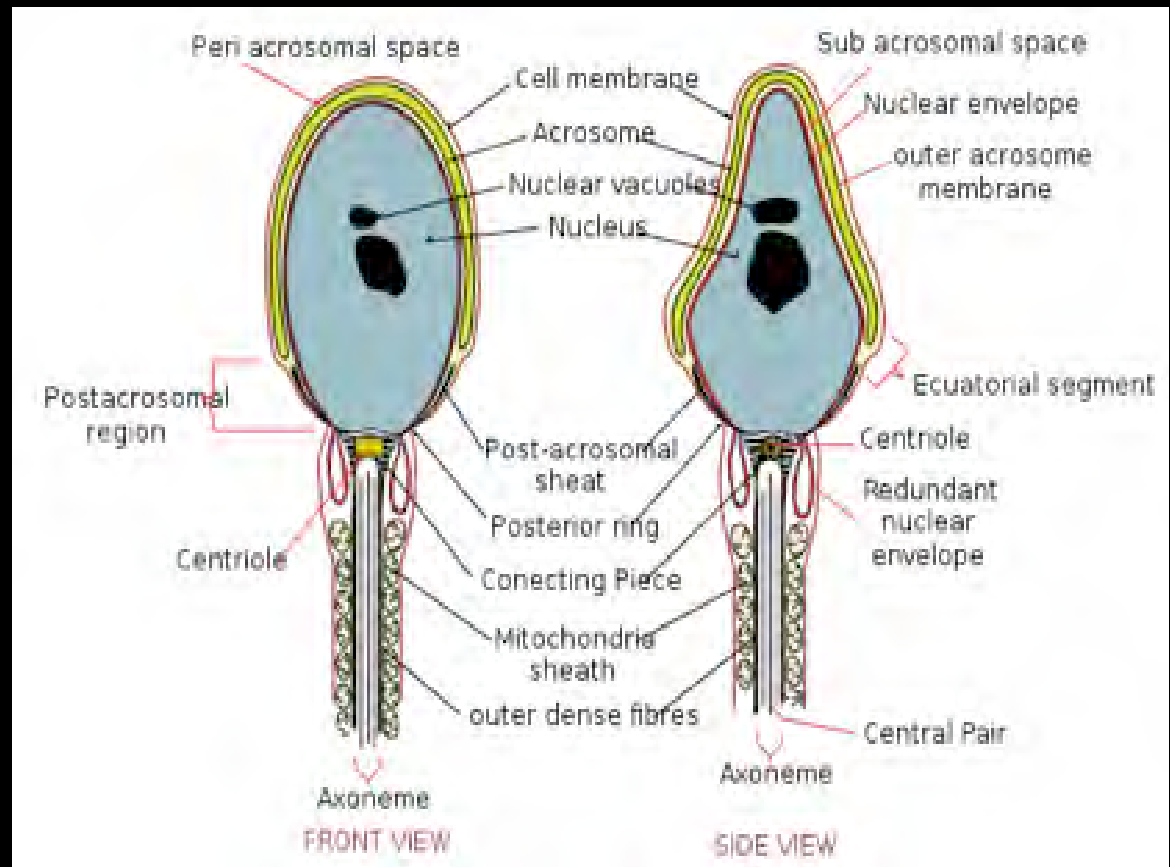


# Sperm. EM drawing. detail



# Sperm head, longitudinal EM section, showing nucleus and acrosome

Acrosome contains enzymes (hyaluronidase, neuraminidase, acid phosphatase, acrosin), which will be released in the "acrosome reaction" at the time of fertilization.

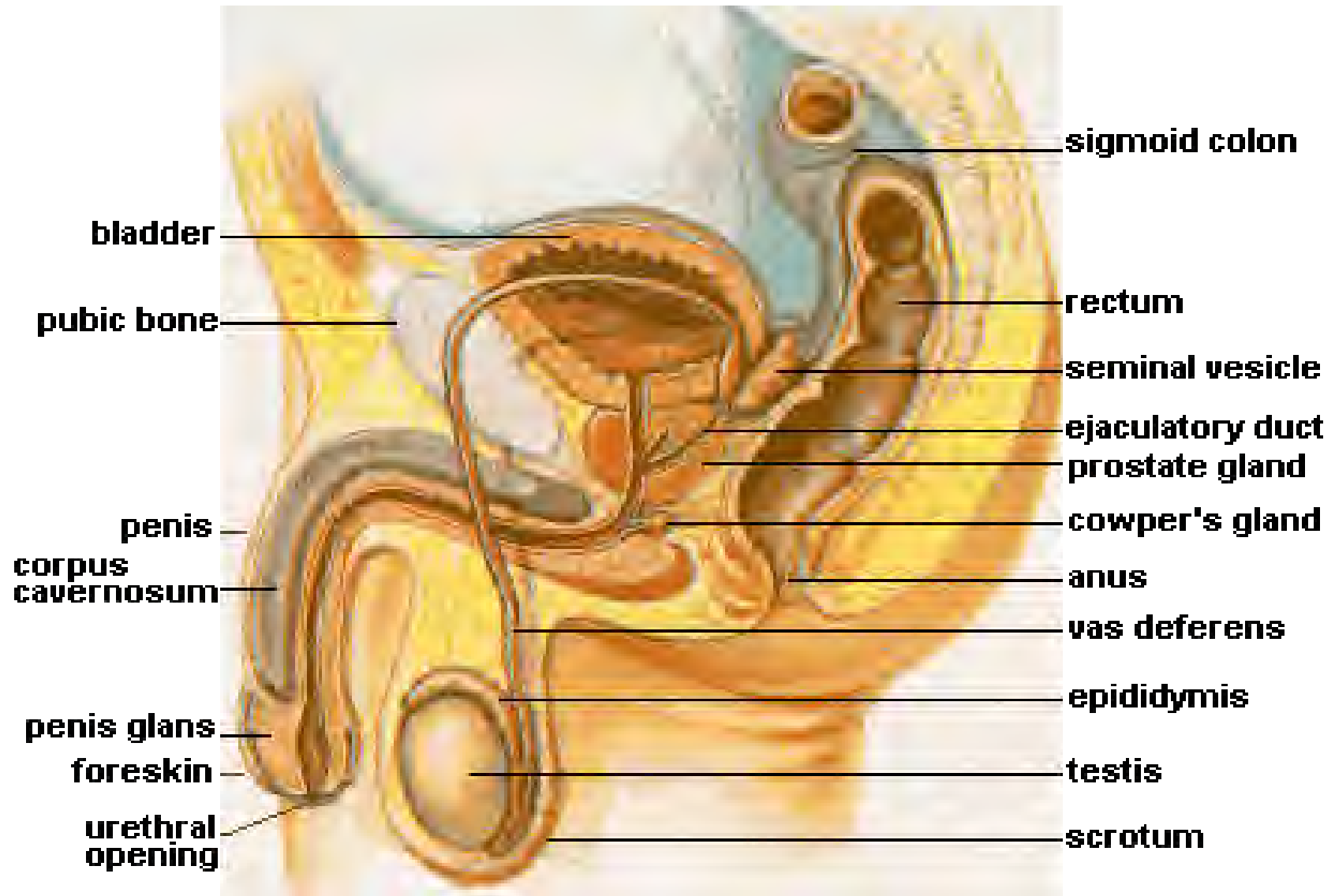




## Middle piece, EM cross section view



# Male reproductive organs



# Testis

The testis has about 250 lobules, each containing 1-4 seminiferous tubules.

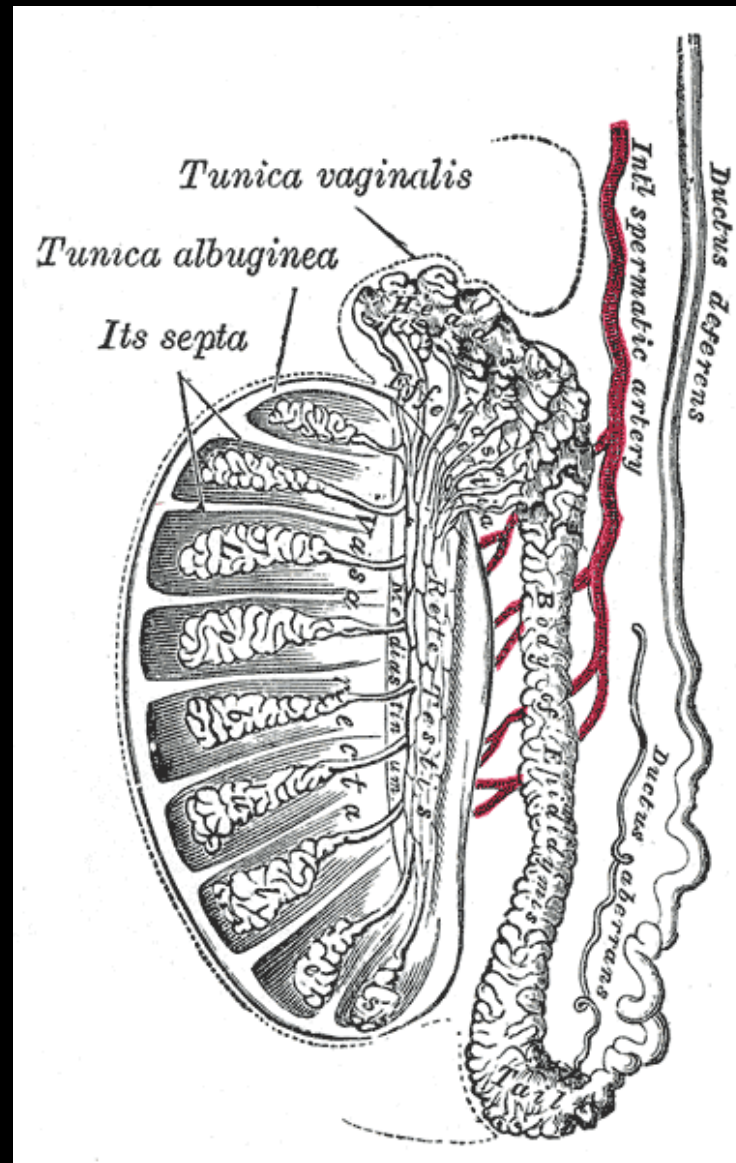
- **Seminiferous tubule**

- Germ cells: Develop into sperm.
- Sertoli cells: Somatic cells, support, nutrition, hormone receptors.
- Boundary layer (flattened fibroblasts).

- **Interstitial tissue**

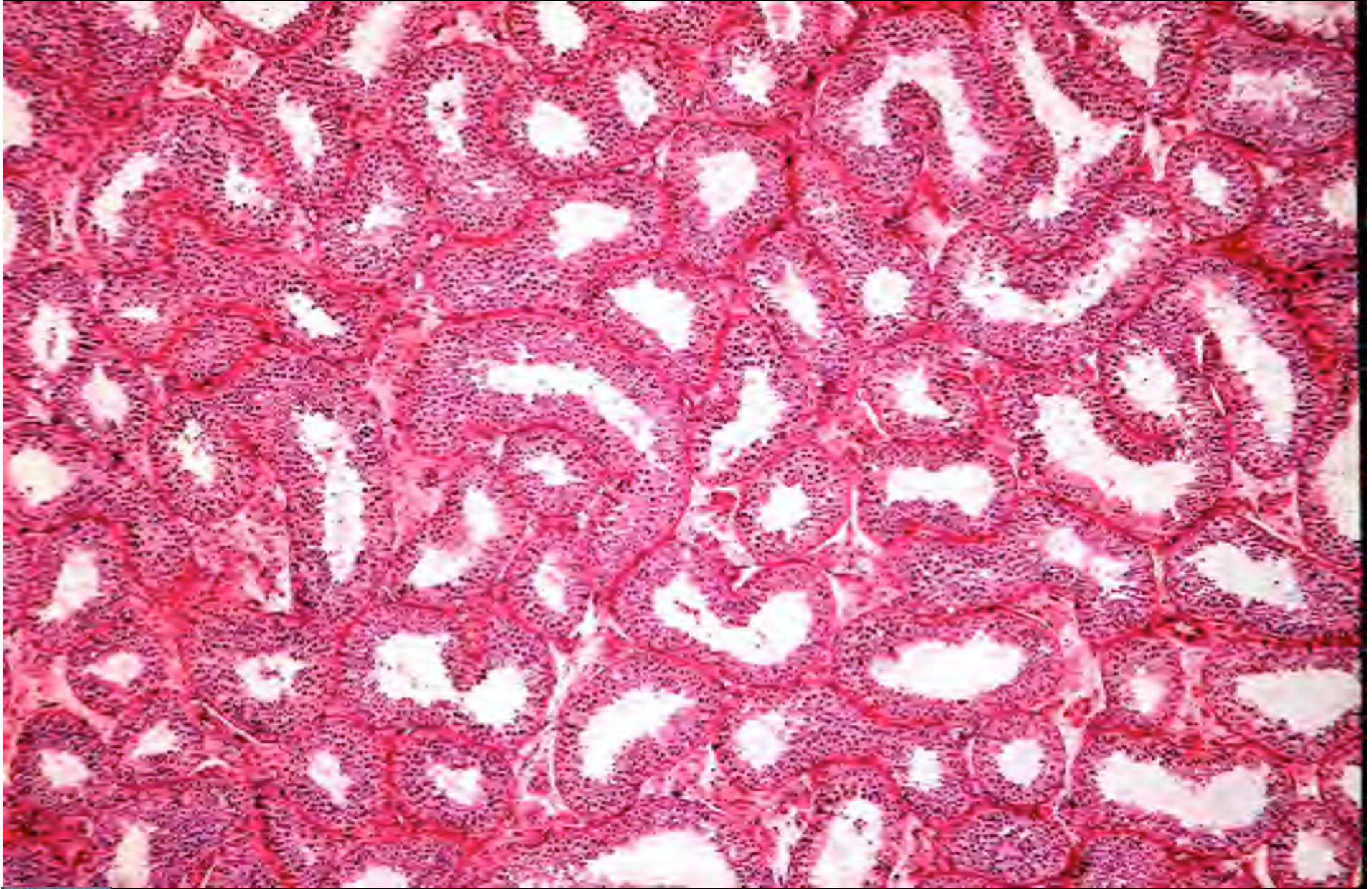
- Leydig cells produce testosterone (a steroid hormone).

# Diagram of testis and epididymis



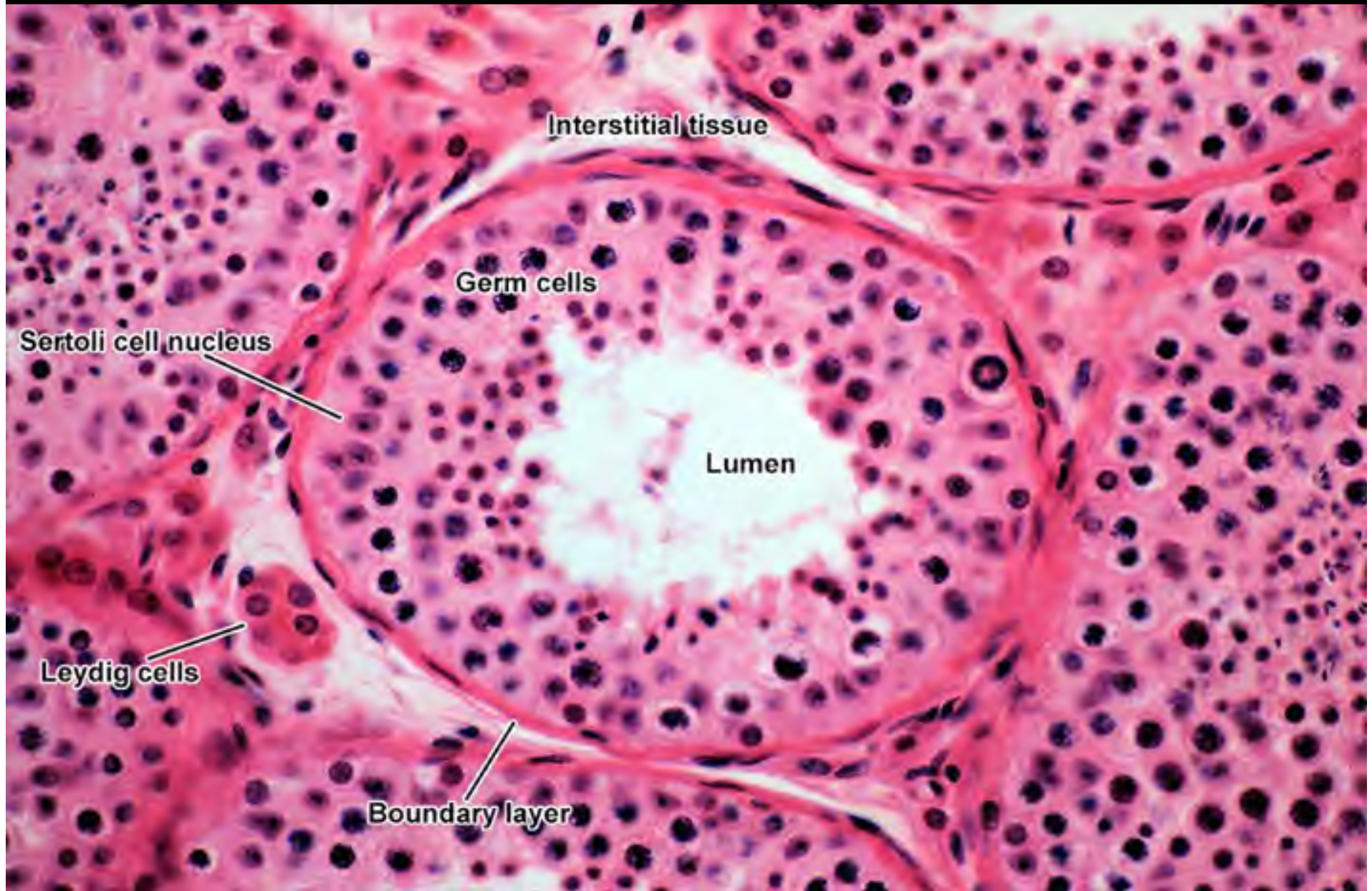


## Testis, low power LM, seminiferous tubules





# Seminiferous tubule and interstitial tissue, human testis, LM

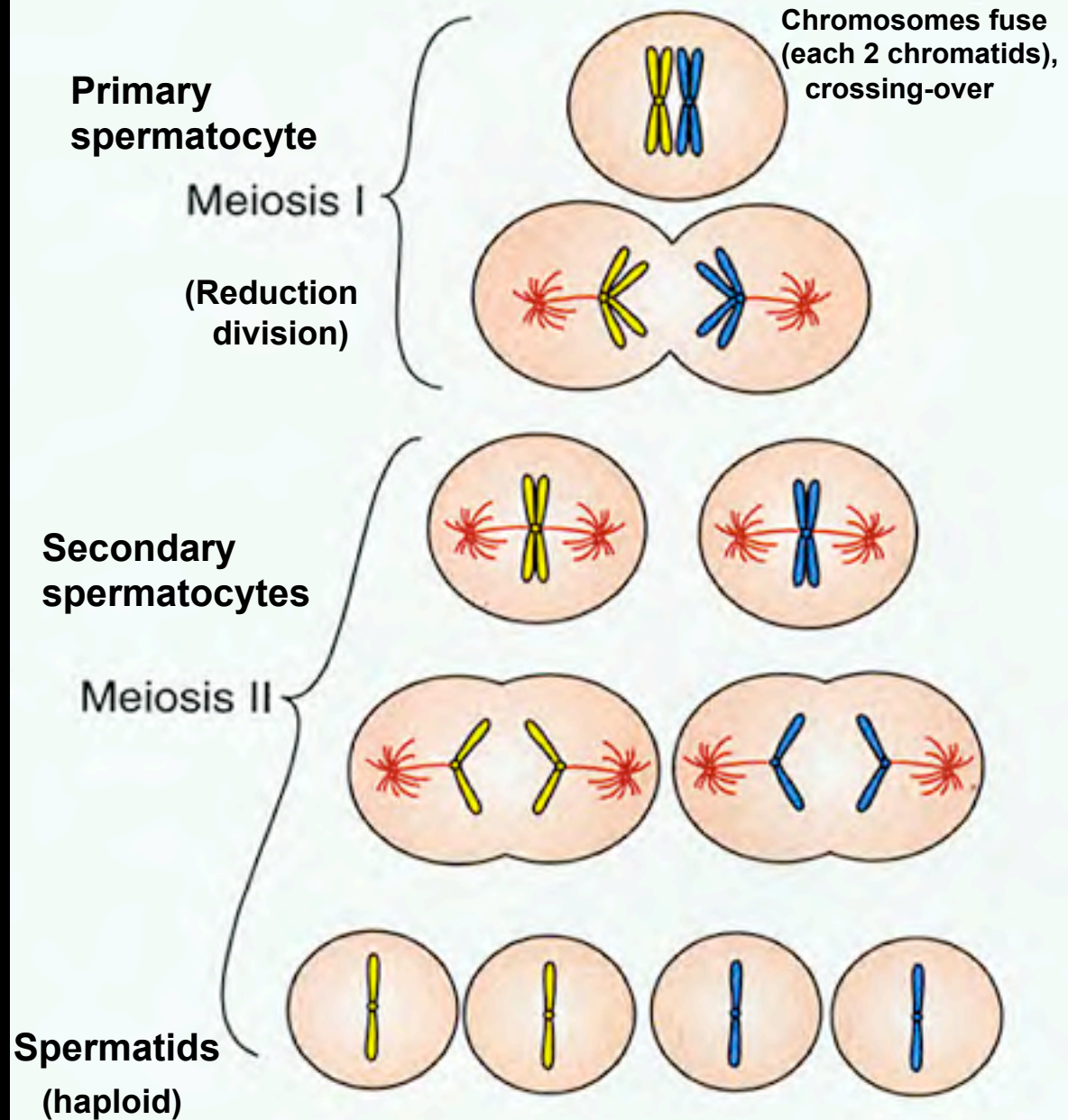


# Spermatogenesis

Development of germ cells into sperm.

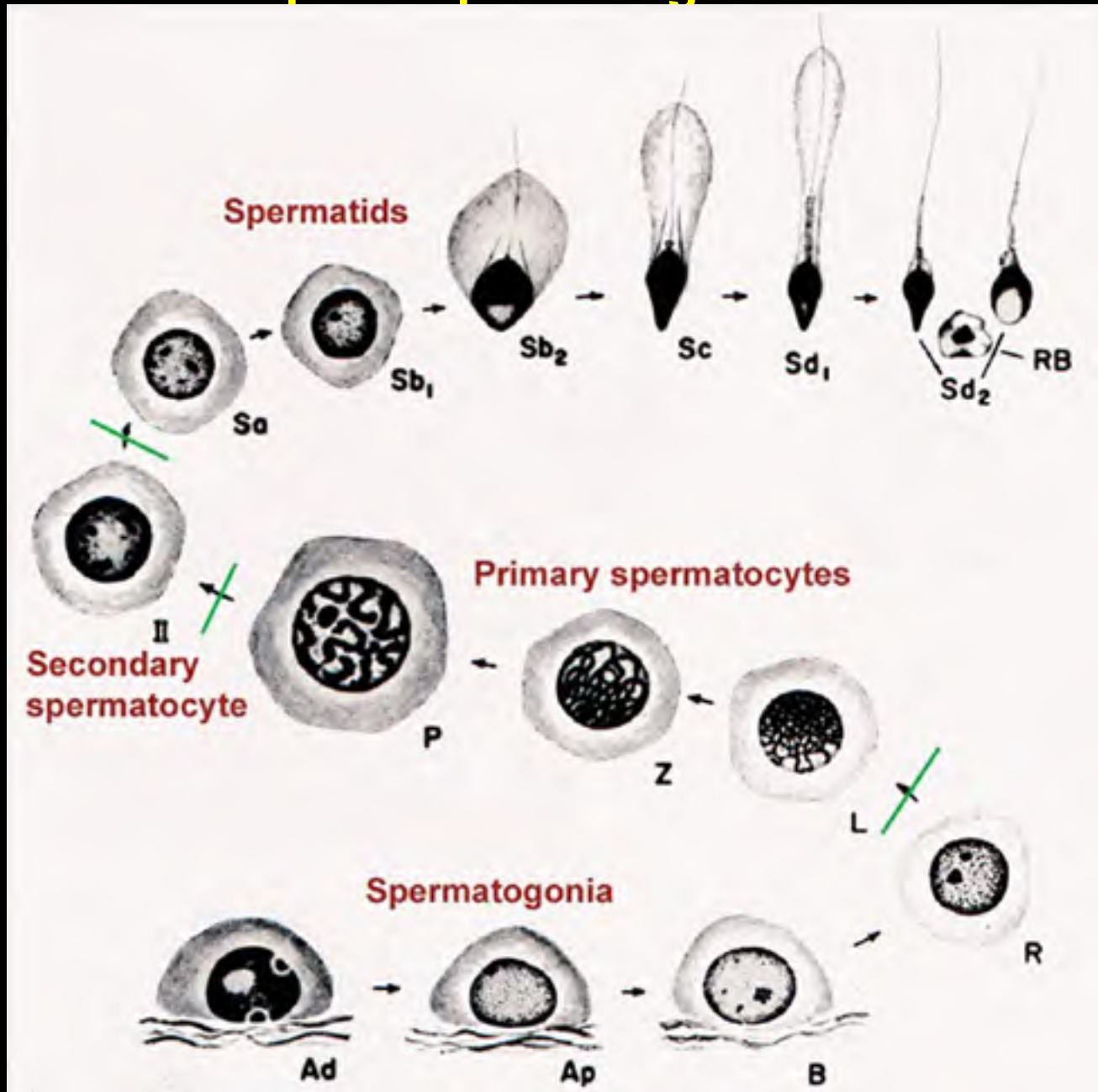
- **Stem cells: Spermatogonia**
  - With 23 pairs of chromosomes (normal amount of DNA).
- **Meiosis: Primary and secondary spermatocytes**
  - Primary spermatocyte: Chromosome pairs fuse, crossing over. Long prophase (about 20 days). First meiotic division, where each daughter cell receives one chromosome from each pair.
  - Secondary spermatocyte: Prompt second meiotic division, which is a normal mitotic division.
- **Spermiogenesis: Spermatids**
  - With 23 chromosomes (half of DNA, for fertilization).
  - Remarkable differentiation into sperm.

# Meiosis

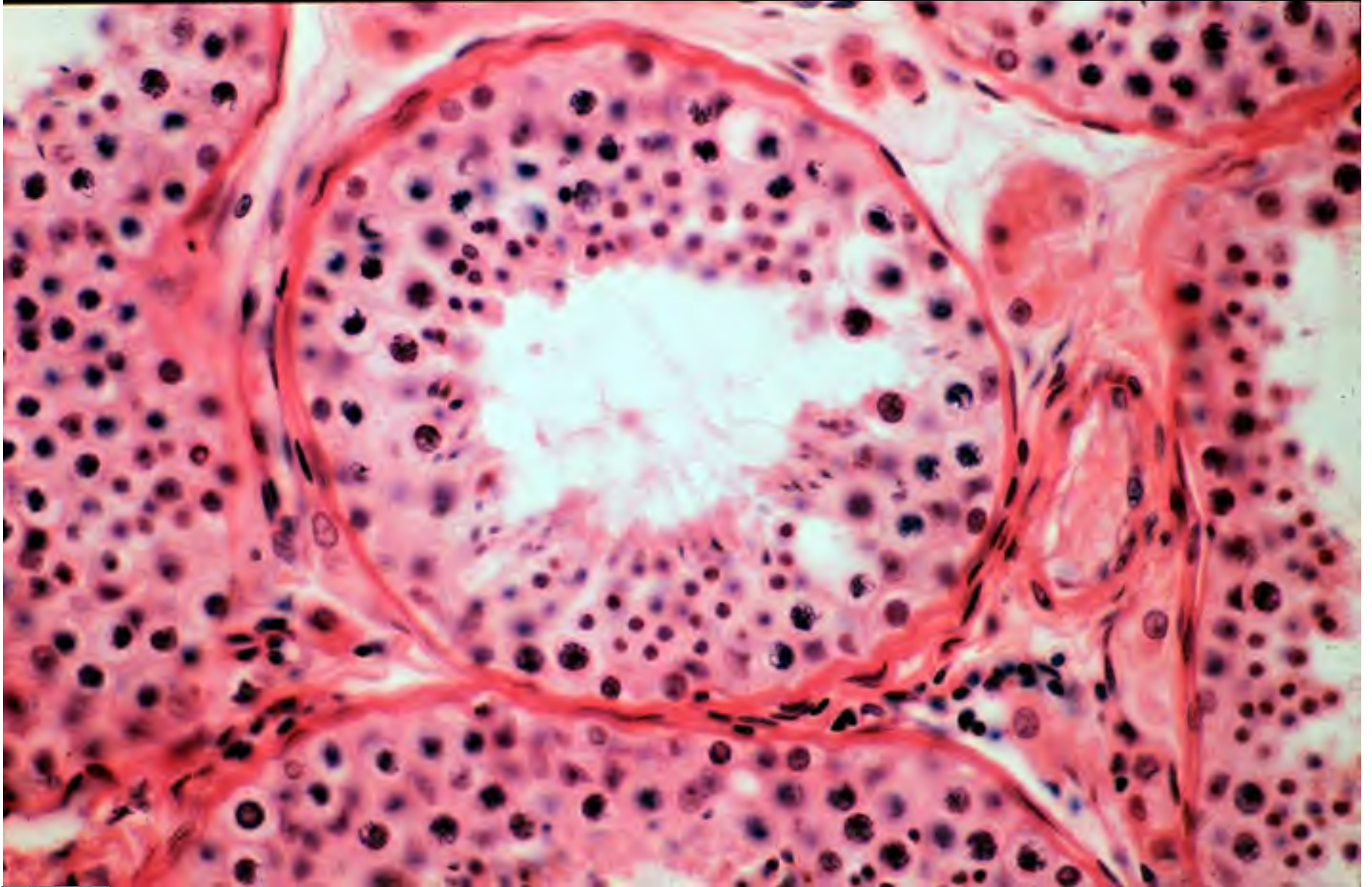




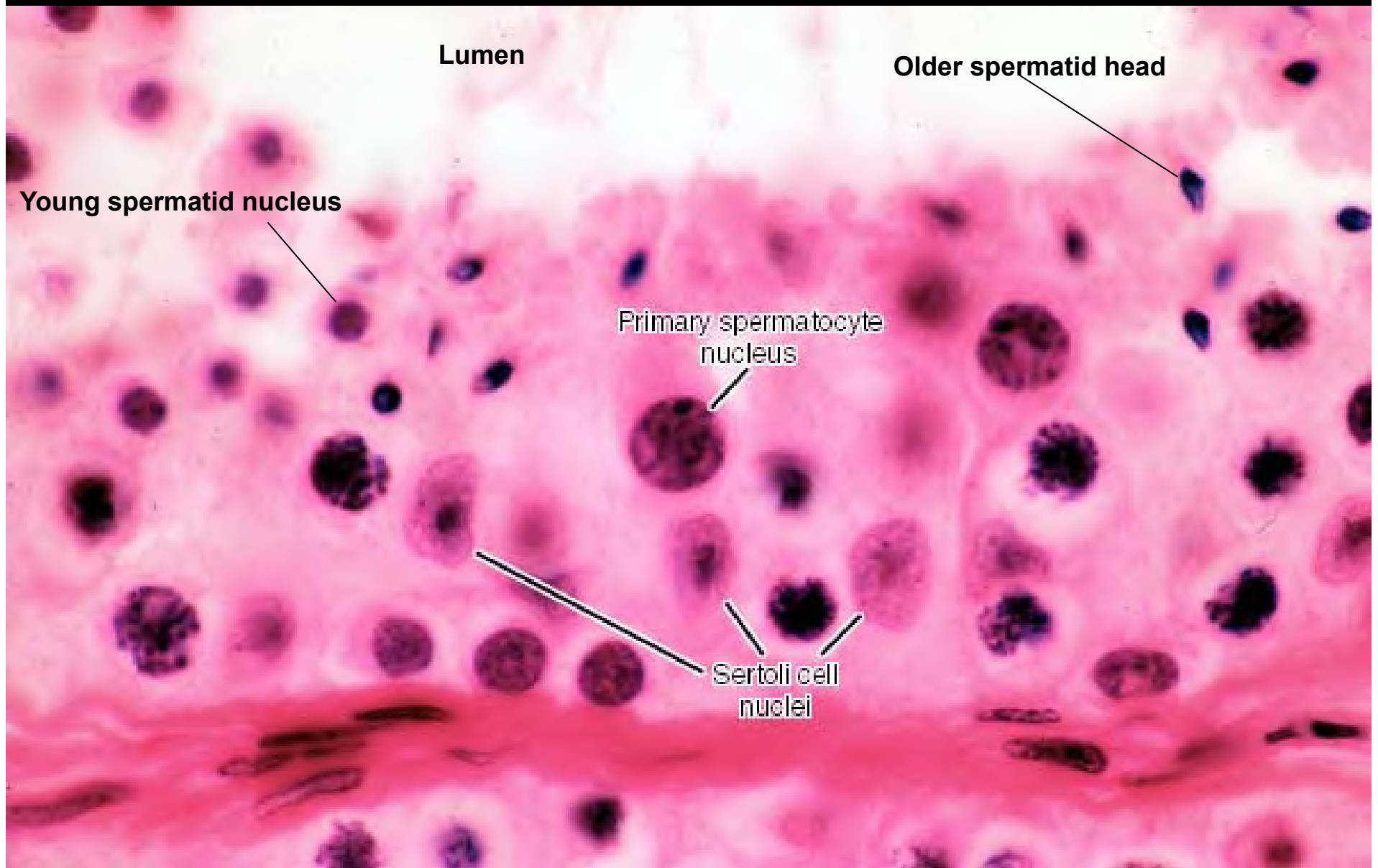
# Steps of spermatogenesis



## Seminiferous tubule, LM

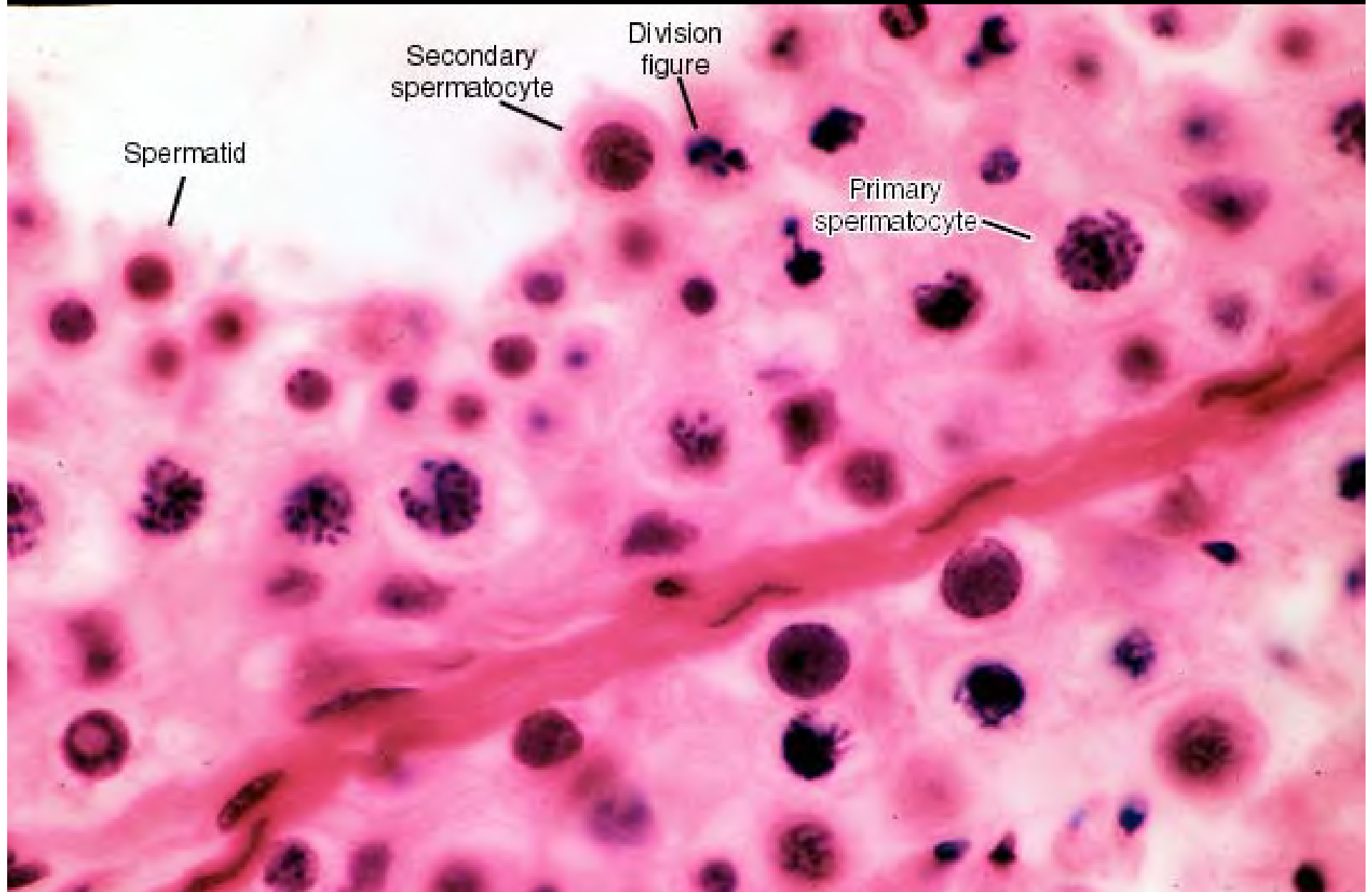


# Primary spermatocytes, spermatids, Sertoli cells

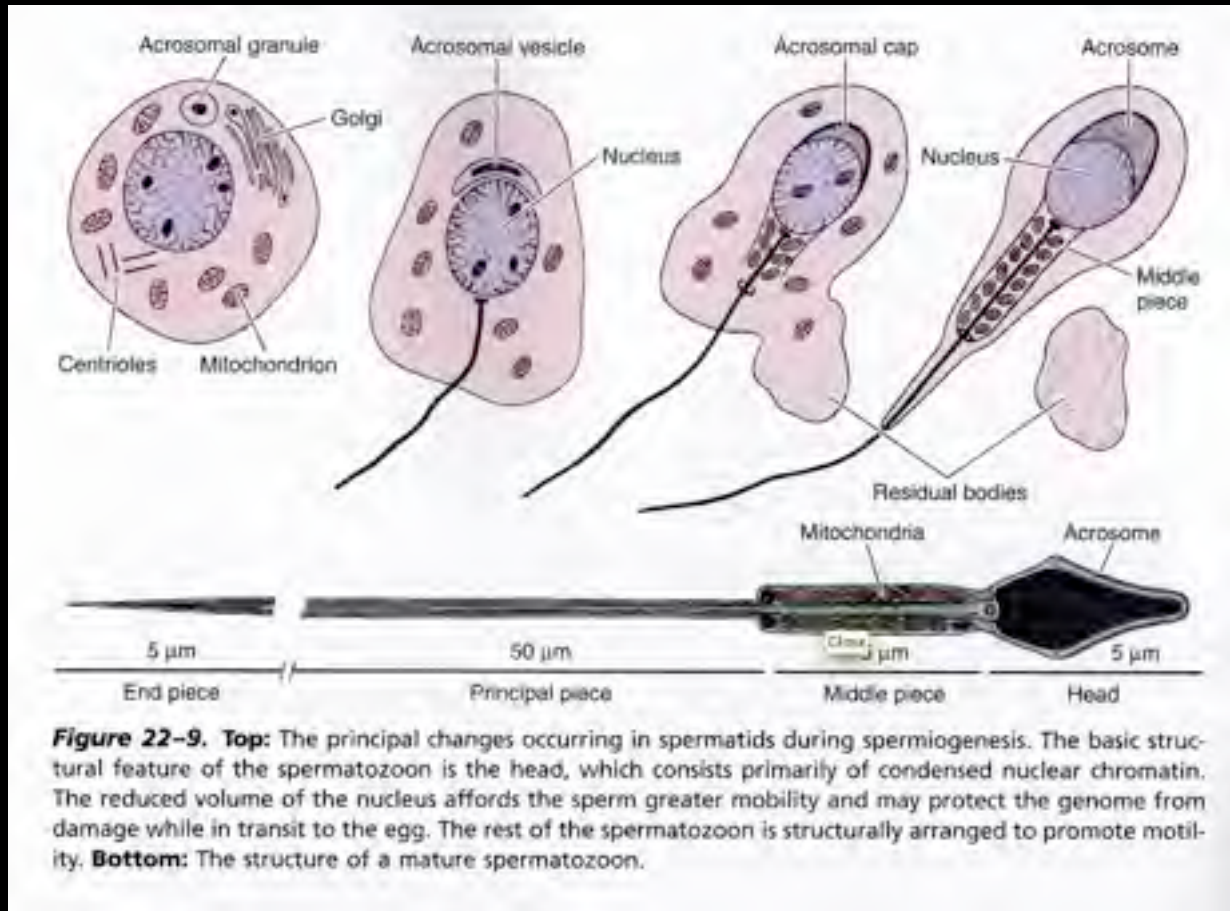




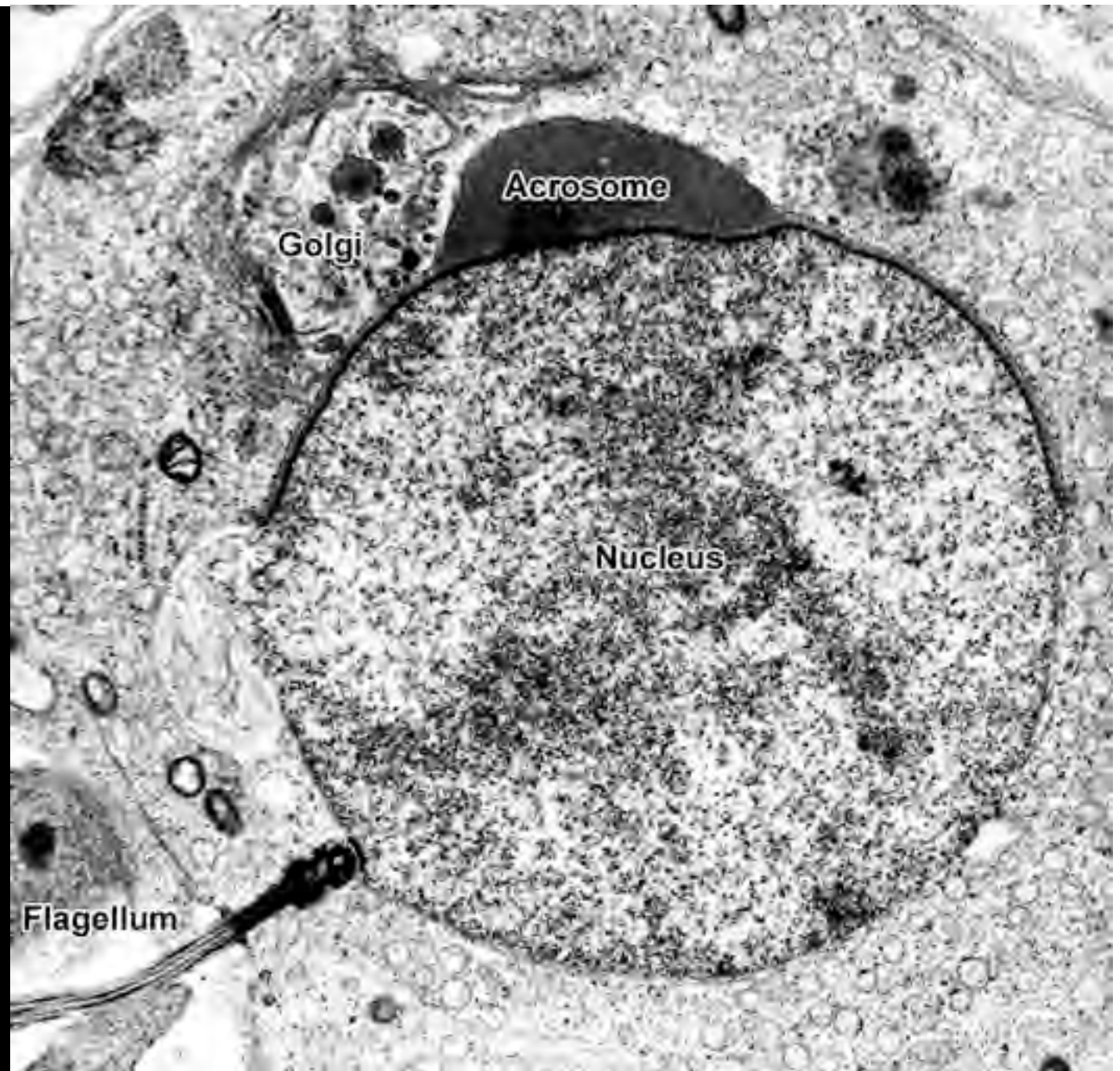
## Secondary spermatocyte, division figures



# Spermiogenesis, diagram



**Spermatid,  
acrosome,  
flagellum,  
EM**





# Sertoli cell

- Cell trunk extends from basement membrane to lumen.
- Supports and nourishes germ cells. All germ cells are surrounded by Sertoli processes or lie in Sertoli surface invaginations.
- Main **endocrine target cell** in the seminiferous tubule.
  - Testosterone receptors.
  - Follicle stimulating hormone (FSH) receptors.
- **Blood-testis barrier** (Sertoli-Sertoli tight junctions).
  - Blocks entrance of extraneous proteins, etc., into seminiferous tubules between Sertoli cells (must go through Sertoli cell).
  - Special fluid inside tubule (high K<sup>+</sup>) made by Sertoli cell.
  - Possible protection of germ cells from immune system.
    - Sperm first arise at puberty, when immune system already set. Sperm surface antigens may be seen as foreign.

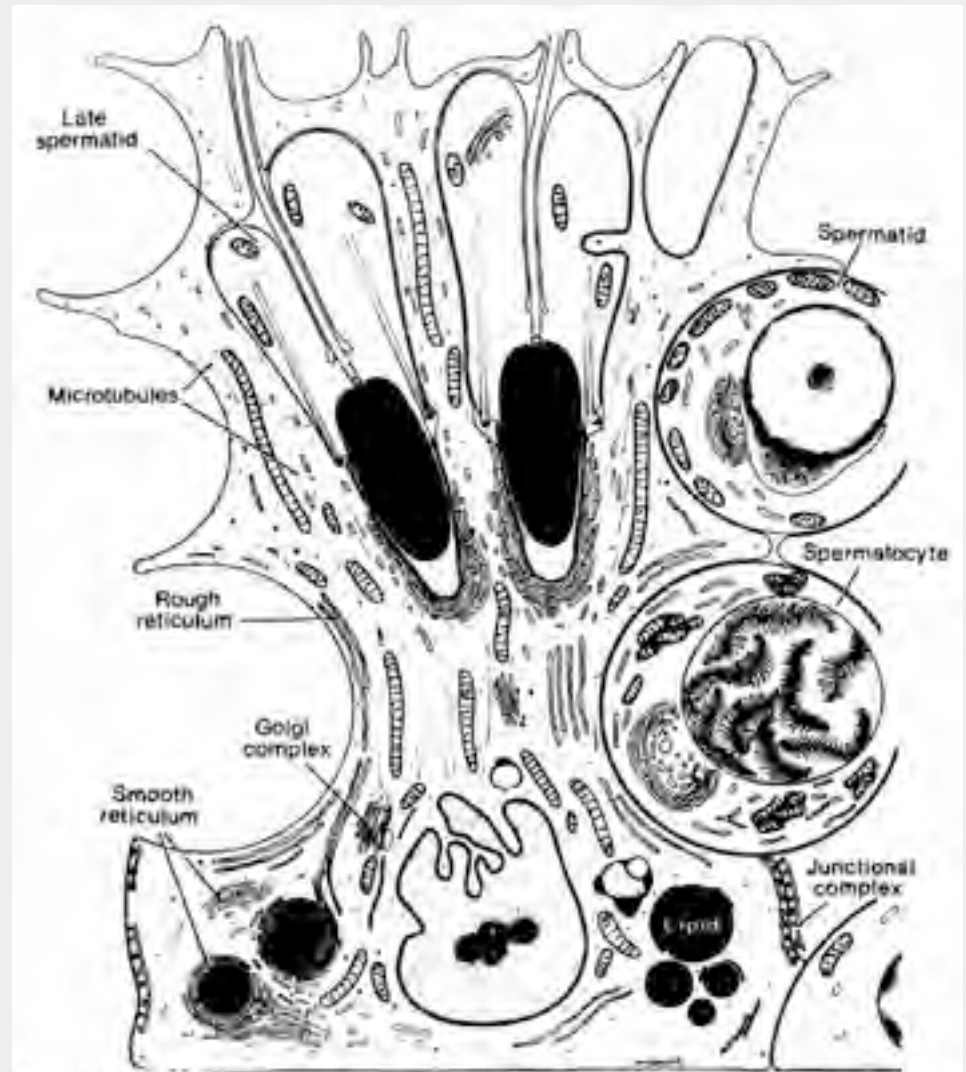
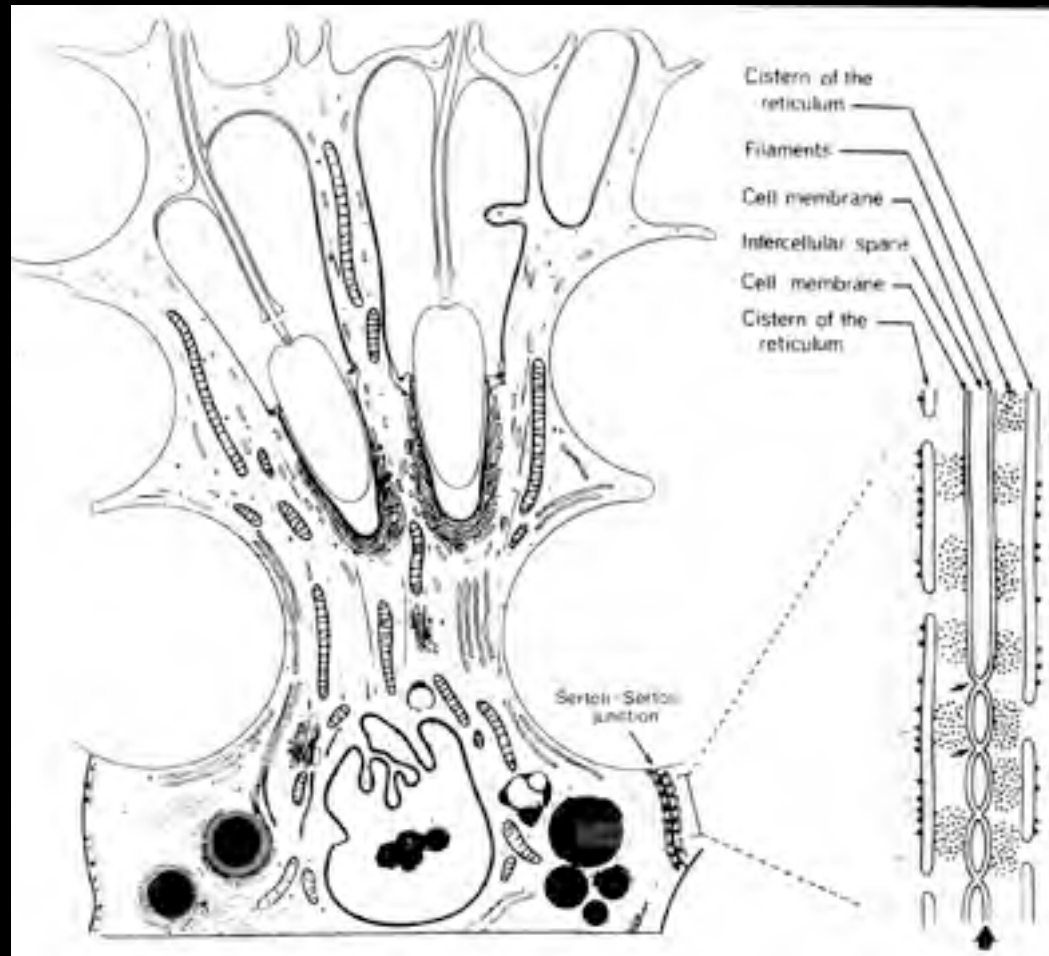


Figure 12-9 Drawing illustrating the ultrastructure of the Sertoli cell and its relationship to the germ cells. The spermatocytes and early spermatids occupy niches in the sides of the columnar supporting cell, while late spermatids reside in deep recesses in its apex. (After D. W. Fawcett, in *Male Fertility and Sterility*, Sertoli Symposium, 1973.)

# Blood-testis barrier (= Sertoli-Sertoli junction)





# Tight junctions of the blood-testis barrier, freeze-fracture, EM



FIG. 13. Electron micrograph of the parallel occluding junctions spaced approximately  $0.1 \mu\text{m}$ , from each other. The particles in the center of the grooves appear to be continuous, but some of them are

separated in short distance. Gap junctions (*g*) of rectangular contour can be seen in E face (*E*) and P-face (*P*). Animal is 40 days old. *Pt.*, *pl.* = 72,000.

# Leydig cell

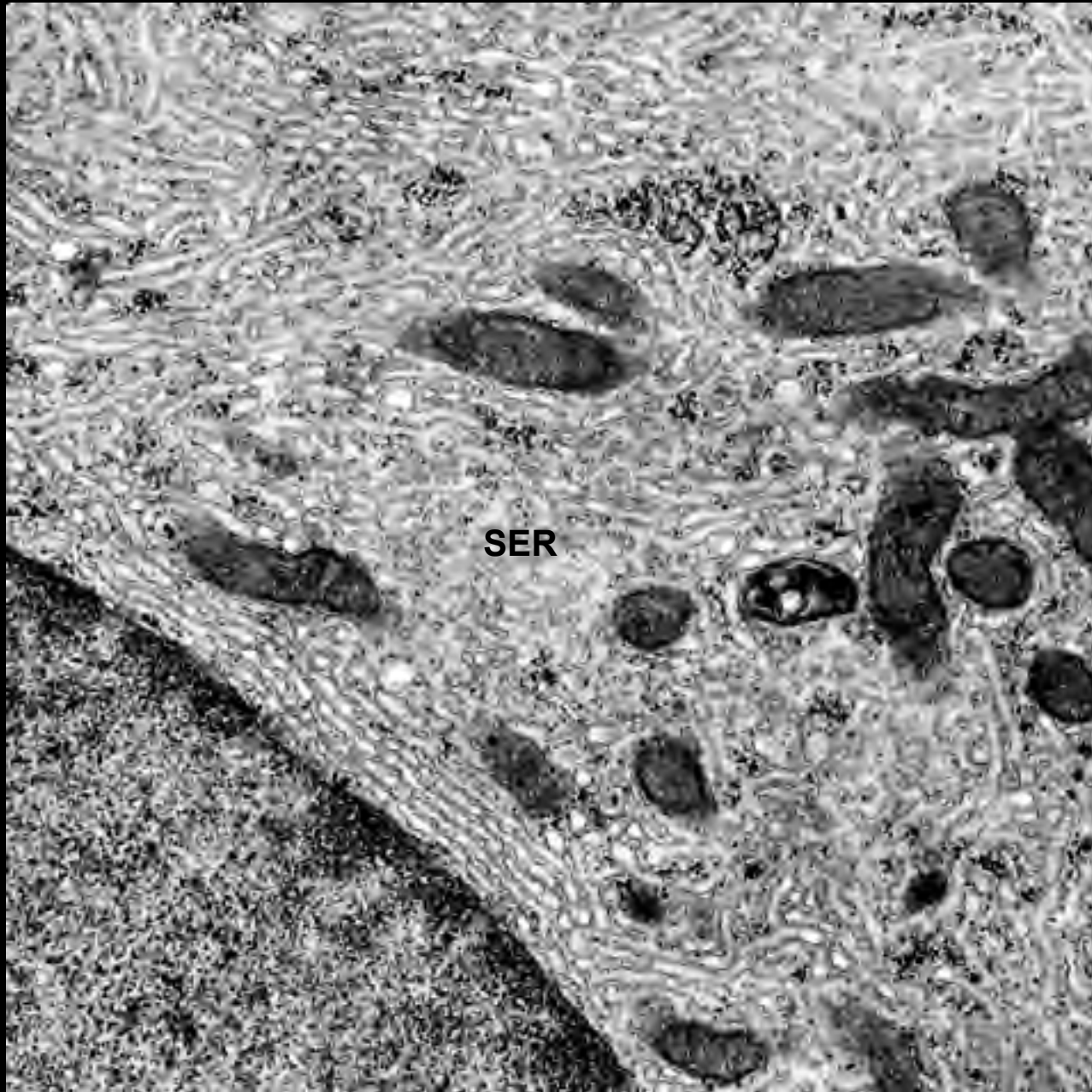
- Source of the male sex hormone **testosterone**, a steroid hormone synthesized from cholesterol. Testosterone is the main testicular androgen.
- Testosterone secretion is regulated by pituitary **LH**.
- A well-developed **smooth endoplasmic reticulum** (SER) is the site of most enzymes of testosterone biosynthesis.



## Leydig cells in the interstitial tissue, testis, LM



# EM of Leydig cell cytoplasm, showing abundant smooth ER

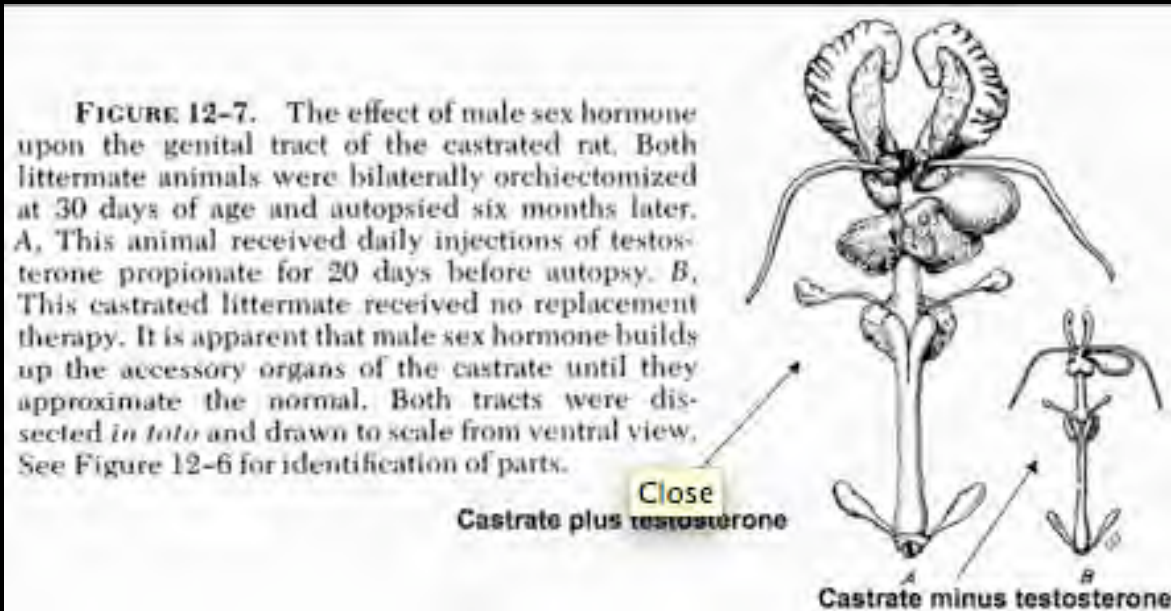


# **Actions of androgen**

- **On Seminiferous tubules**
  - Testosterone is the main hormone regulating spermatogenesis. It acts on Sertoli cells, which have androgen receptors.
- **On the male reproductive tract**
  - Androgen regulates development and maintenance of most of the tract. Dihydrotestosterone(DHT).
- **On male secondary sexual characteristics, which arise at puberty**
  - Muscle tone and strength.
  - Lower voice.
  - Axillary and pubic hair.
  - Beard and dense body hair, acne.
  - Receding hairline and baldness (also genetic).



# Action of testosterone on the male tract, rat



# Pituitary regulation of male reproduction

- **Luteinizing hormone (LH)**

- Regulates androgen secretion by Leydig cells. The androgen then regulates spermatogenesis, the male tract and male secondary sexual characteristics.
- LH receptors are on the plasma membrane of Leydig cells.

- **Follicle stimulating hormone (FSH)**

- Regulates the establishment of spermatogenesis at puberty.
- FSH receptors are on the plasma membrane at the basal surface of Sertoli cells.
- Although Sertoli cells in the mature testis have FSH receptors that probably have some functions, FSH does not appear to be essential for spermatogenesis in the adult testis.

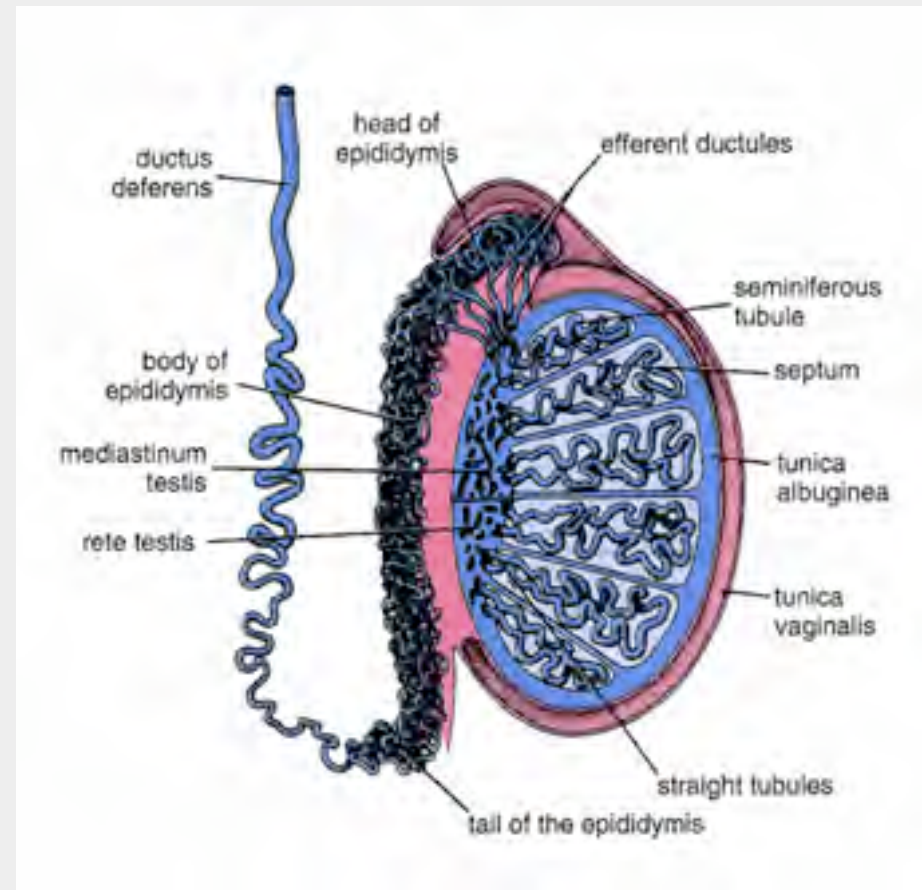
**Testis of a rat from which pituitary removed  
(= hypophysectomy), LM**






# Sperm pathway through the male tract

- **Mediastinum of the testis.**  
Straight tubules. Rete testis.
- **Efferent ducts.** Passageway from testis to epididymis. There are 15-30 efferent ducts.
- **Epididymis.** Head, body, tail. Single long coiled duct (~6 m long). Sperm mature during passage, and are stored in the tail of the epididymis (for ejaculation).
- **Ejaculation**
  - Ductus deferens conducts sperm from epididymal tail.
  - Seminal vesicles usually furnish most of seminal fluid.
  - Prostate gland contributes to seminal fluid.
  - Semen passes through prostatic and penile urethra.



 **BY-NC-ND** Ross and Pawlina, 5th ed, 2007, fig 22.4a, pg 732.



# Mediastinum (dense irreg. C.T.), rete testis (channels), LM





## Efferent duct, epididymis, LM





## Efferent duct (star-shaped lumen)





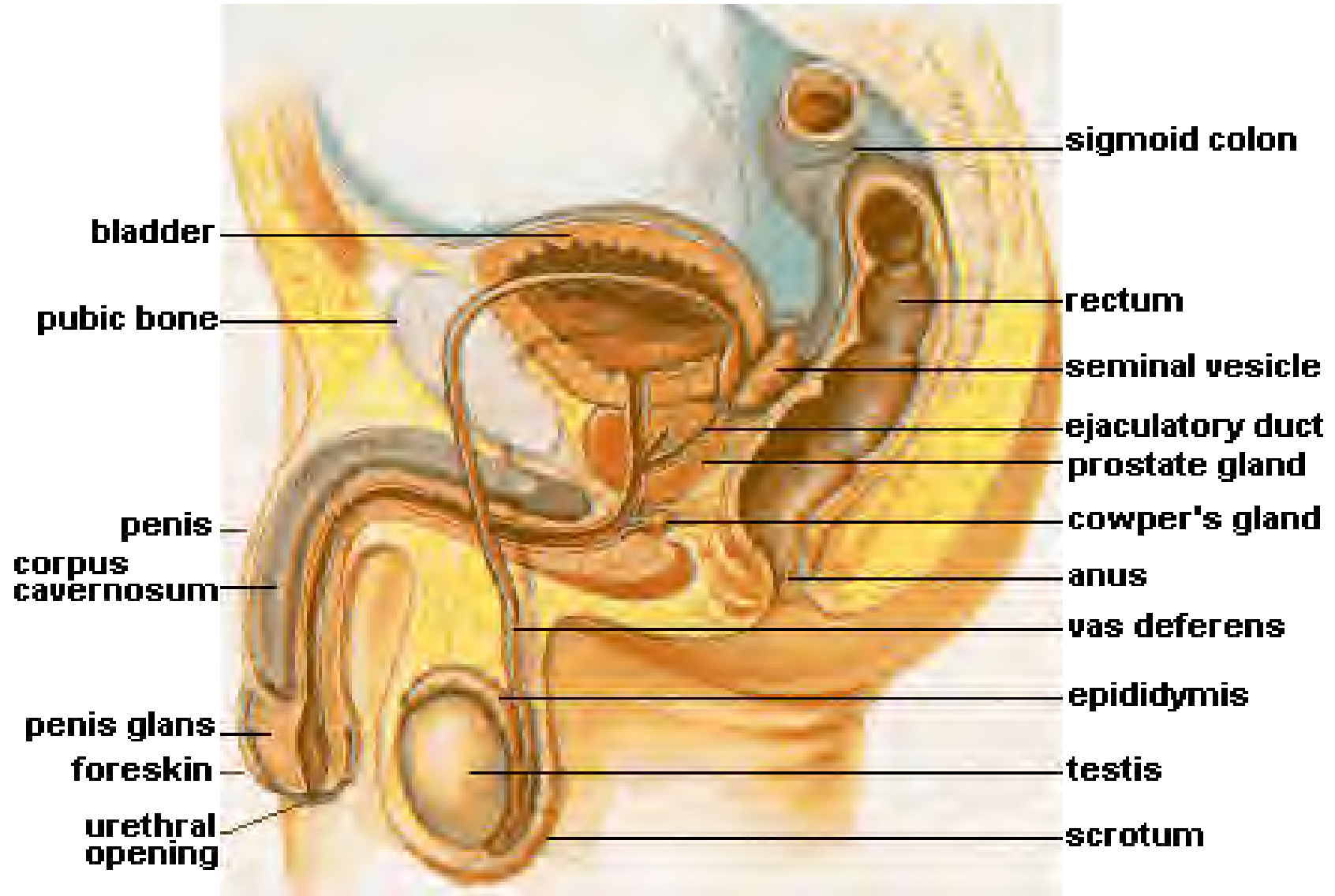
# Epididymis (pseudostratified columnar epithelium)



**The scrotum keeps testis about 2° cooler than rest of body. If not, then testis inactive (= cryptorchidism)**

Image of cryptorchidism and ectopia removed. Original here: Ciba Collection of Medical Illustrations, by Frank Netter.

# Male reproductive tract





# Spermatic cord: ductus (vas) deferens, testicular artery, pampiniform plexus of veins, cremaster muscle, LM





# Semen

**Normally about 3.5 ml per ejaculate in humans.**

- **Sperm**

- **About 100 million sperm per ml. Concentrations lower than about 20 million/ml may cause fertility problems.**

- **Seminal fluid**

- **Mainly from seminal vesicle (usually about 70%), prostate and epididymis.**

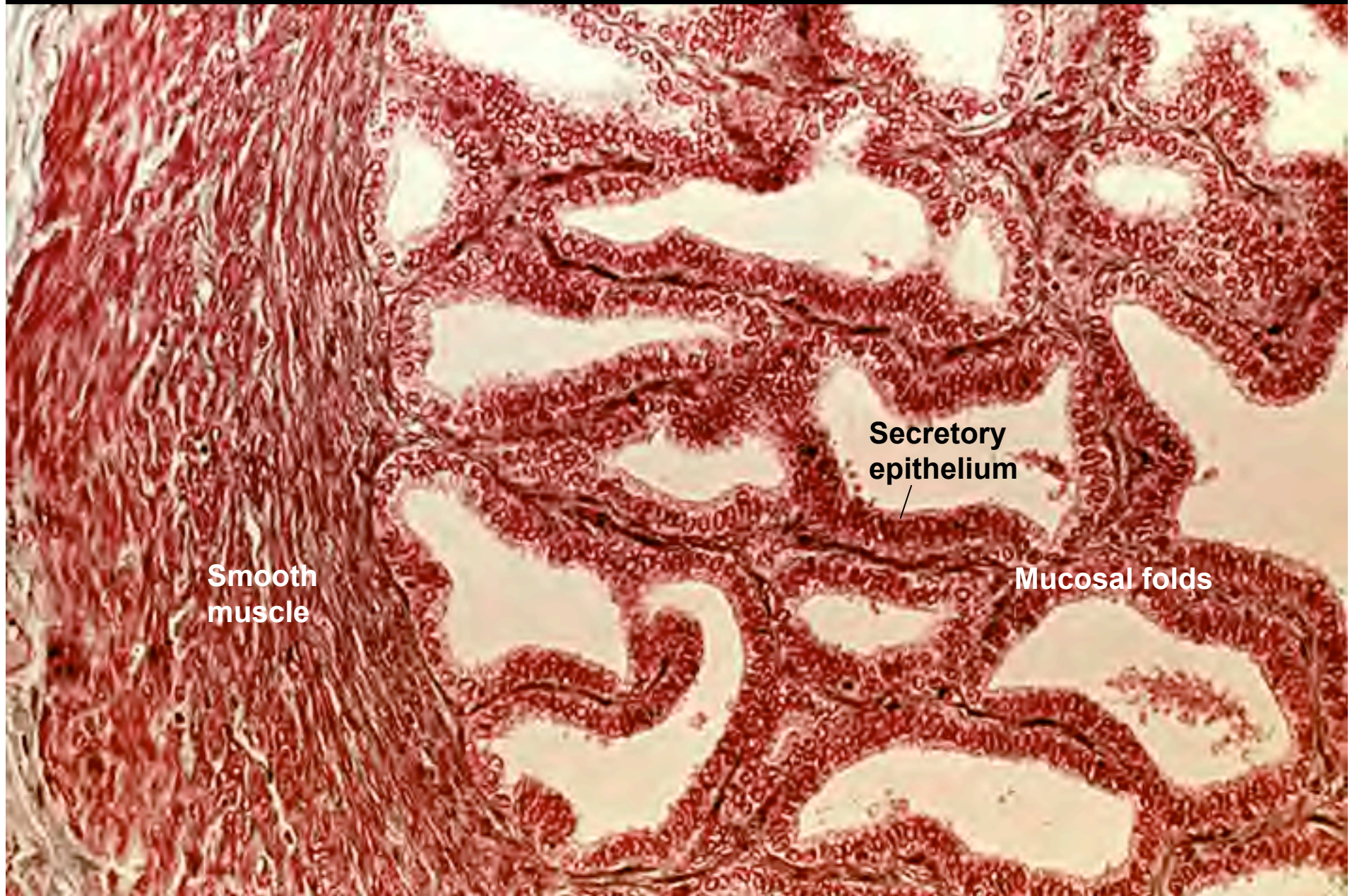
## Seminal vesicle, human, low power LM

The secretion includes fructose, ascorbic acid, prostaglandins.





## Seminal vesicle, LM



Smooth  
muscle

Secretory  
epithelium

Mucosal folds

## Prostate gland

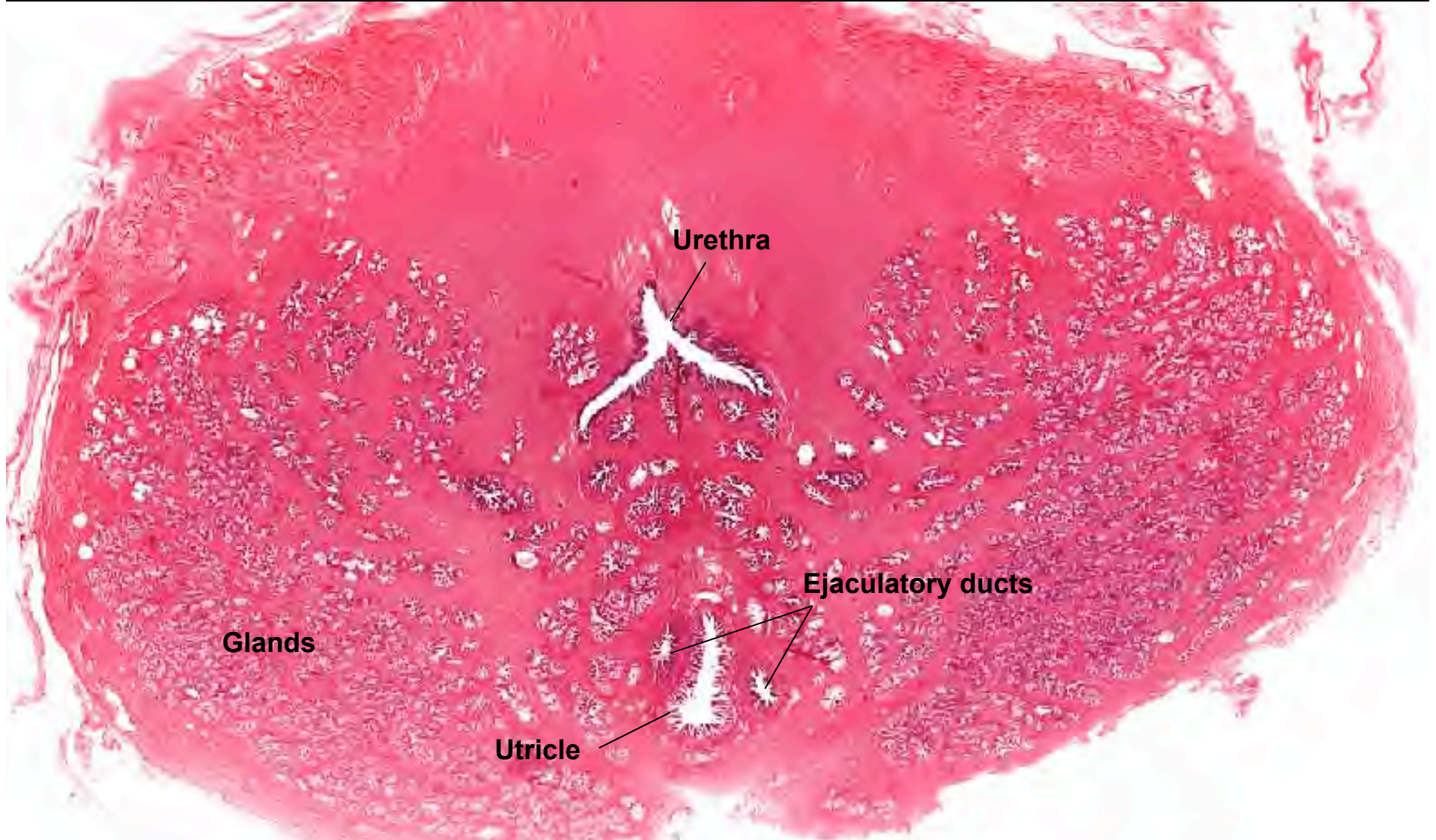
**Drawing of glands in a fetal prostate. Compound tubuloalveolar glands, each emptying separately into the prostatic urethra. Below is a cross section of the fetal prostate.**

Image of fetal prostate glands removed. Original here: Campbell M.F. & Harrison J.H., 1970, Urology, vol. 1, ed. 3, page 141



## Adult prostate gland, cross section, low power LM.

There are 30-50 compound tubuloalveolar glands. The secretion is expelled into the semen during ejaculation. The contents include acid phosphatase, citric acid, fibrinolysin, and prostate-specific antigen (PSA).



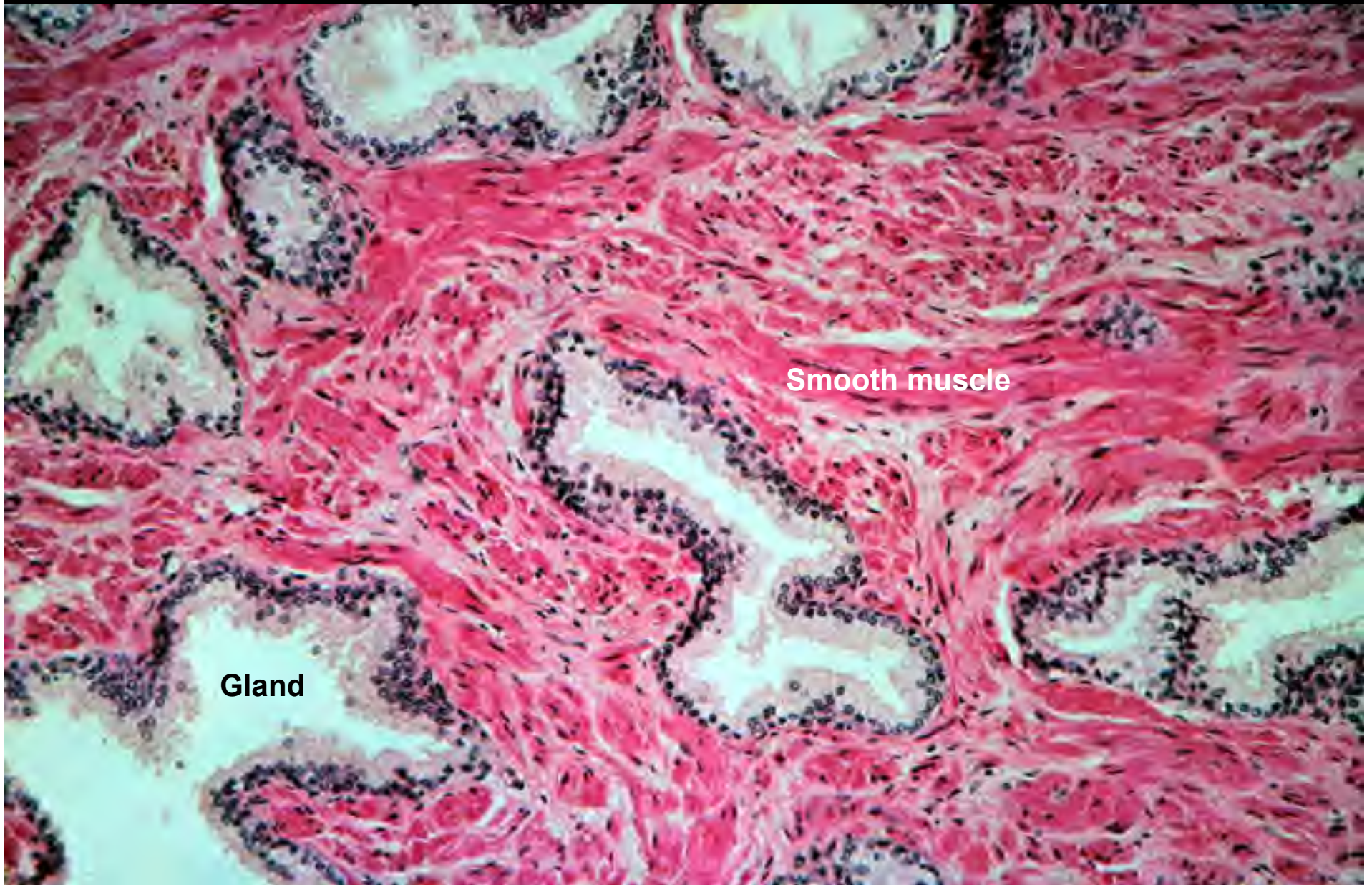
# Prostate Gland

- The glands are organized into three rather indistinct zones:
- (1) **Mucosal** (or urethral) glands.
- (2) The **main** (or peripheral) glands occupy about 70% of prostate volume.
- (3) **Submucosal** (or median) glands are located anteriorly between the mucosal and main glands.
- **Benign prostatic hypertrophy (BPH, nodular hyperplasia)** is common in men over 50 years of age. It occurs primarily in the mucosal and submucosal glands, sometimes giving rise to urethral obstruction.
- **Prostatic cancer (carcinoma)** is the second most frequent cause of death from cancer in U.S. males. Carcinomas occur primarily in the main (or peripheral) glands.

Image of normal human prostate removed. Original here: Martin Dym in Leon Weiss, Cell and Tissue Biology, 6th ed., 1988, Urban & Schwarzenberg (Baltimore), fig 30-44, page 967.



## Detail of prostate glands, LM





# Prostate gland, concretions (= amyloid bodies), composed of calcified glycoproteins

Concretion



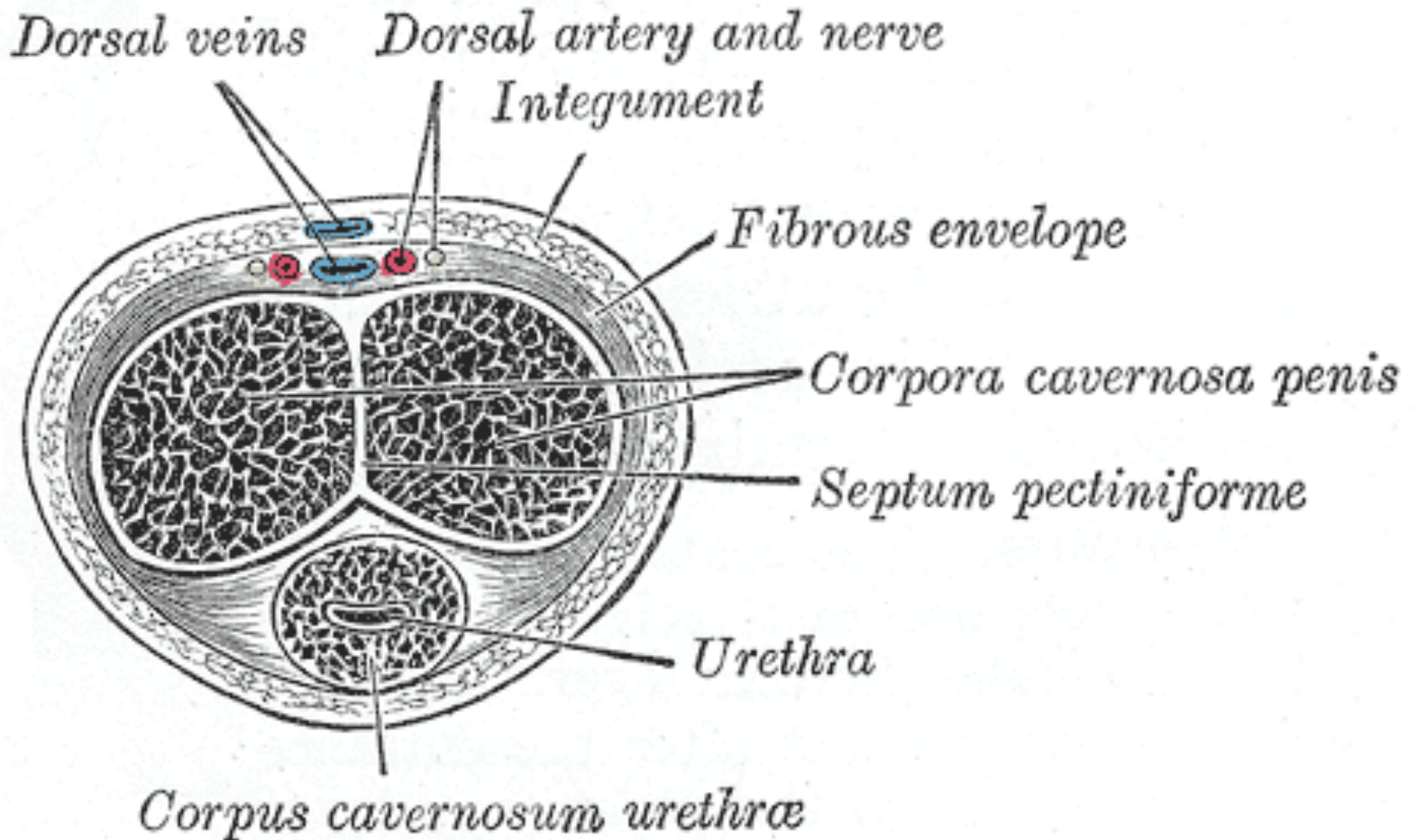
Gland

Smooth  
muscle





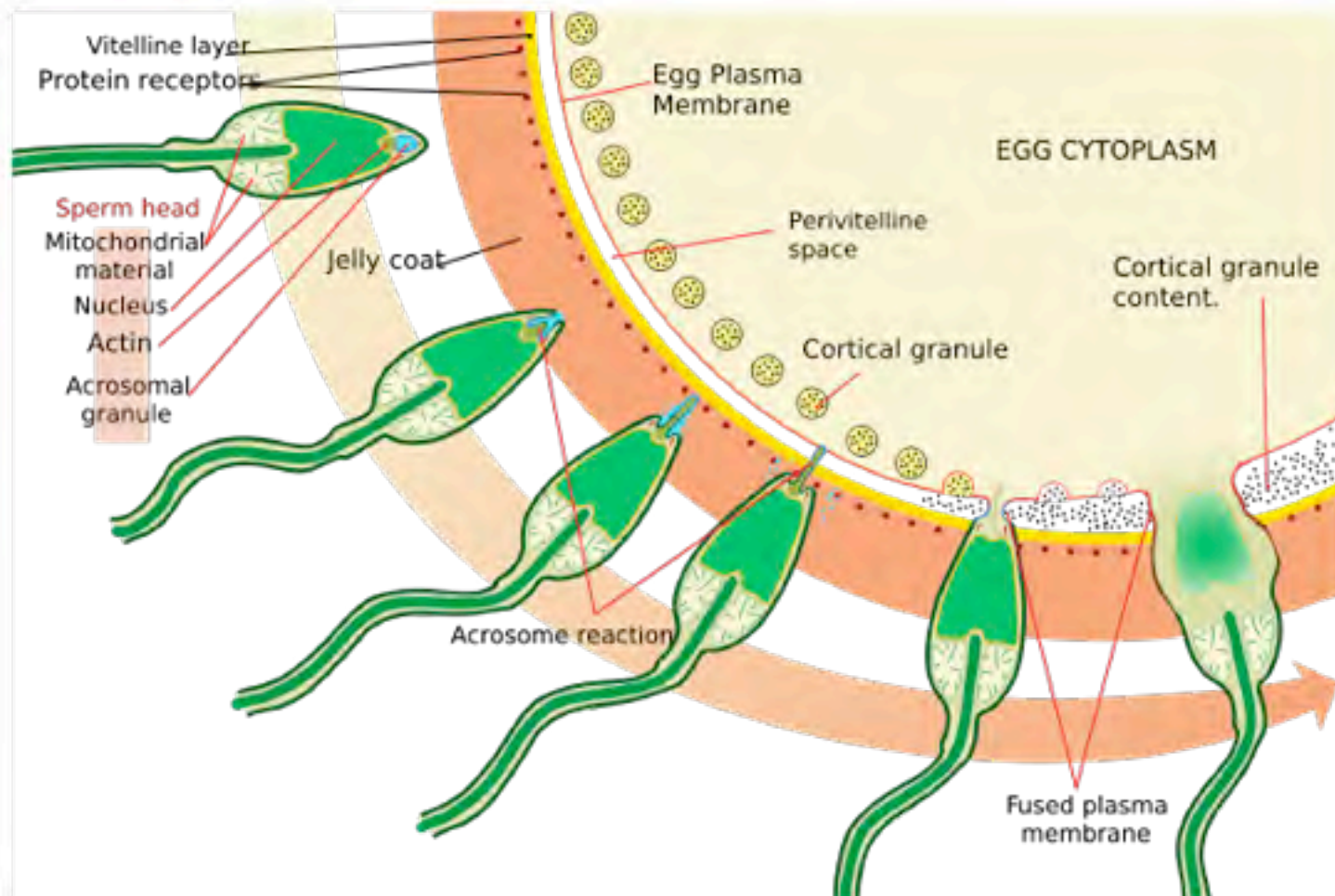
## Penis cross section, LM drawing



# Fertilization

- Semen is deposited in the female tract.
- **Cervix:** Ability of sperm to pass depends on the consistency of cervical mucus.
- Lumen of uterus and oviducts: Sperm undergo "**capacitation**," an induced change that will allow sperm to undergo subsequent acrosome reaction.
- Events in vicinity of ovum (usually in the ampulla of the oviduct):
  - Secretion from the ovum induces sperm to undergo an **acrosome reaction**, releasing acrosomal hydrolytic enzymes that may facilitate sperm entry through the cumulus and zona pellucida of the ovum.
  - A sperm **enters the ovum**. Subsequent sperm are excluded.
  - Fusion of the female and male pronuclei yields a nucleus with 23 pairs of chromosomes, the beginning of a **new individual**.

# Fertilization: acrosome reaction releases hydrolytic enzymes that help sperm reach the surface of the egg



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